Alaska Division of Geological & Geophysical Surveys

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COLOR-INDEXED ELEVATION MAPS FOR FLOOD-VULNERABLE COASTAL COMMUNITIES IN WESTERN ALASKA

by

Jacquelyn Overbeck, Katrina Kennedy, and Rebecca Heim

Example area of color-indexed map of Teller

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3354 College Road, Fairbanks, Alaska 99709-3707

dggspubs@alaska.gov | dggs.alaska.gov

Note: *This report, including all digital data, explanations, and tables, is available in digital format from the DGGS website (http://dggs.alaska.gov).*

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Jacquelyn Overbeck[1], Katrina Kennedy[1], and Rebecca Heim[2]

UPDATE SUMMARY

Version 2 of MP 154 is an update to 3 of the original 5 communities; in addition, color-indexed maps have been created for the first time at 8 communities (fig. 1). For the original documentation of methods used to create the color-indexed maps, please reference Tschetter and others (2014). Similar to the original map series, version 2 maps are accompanied by a tide staff reference sheet that is a separate but associated legend for maps from each community. These reference sheets are separate so they can be updated more frequently than the mapped datasets. The map and tide staff show elevations and conversions necessary to project forecasted flood events at individual communities and to communicate potential for flooding.

Recently collected elevation data over a large region of western Alaska were utilized to modify this map series (Overbeck and others, 2016). As with the original map series, all infrastructure, boundary, and land-use delineations have been provided by the Alaska Department of Community and Regional Affairs

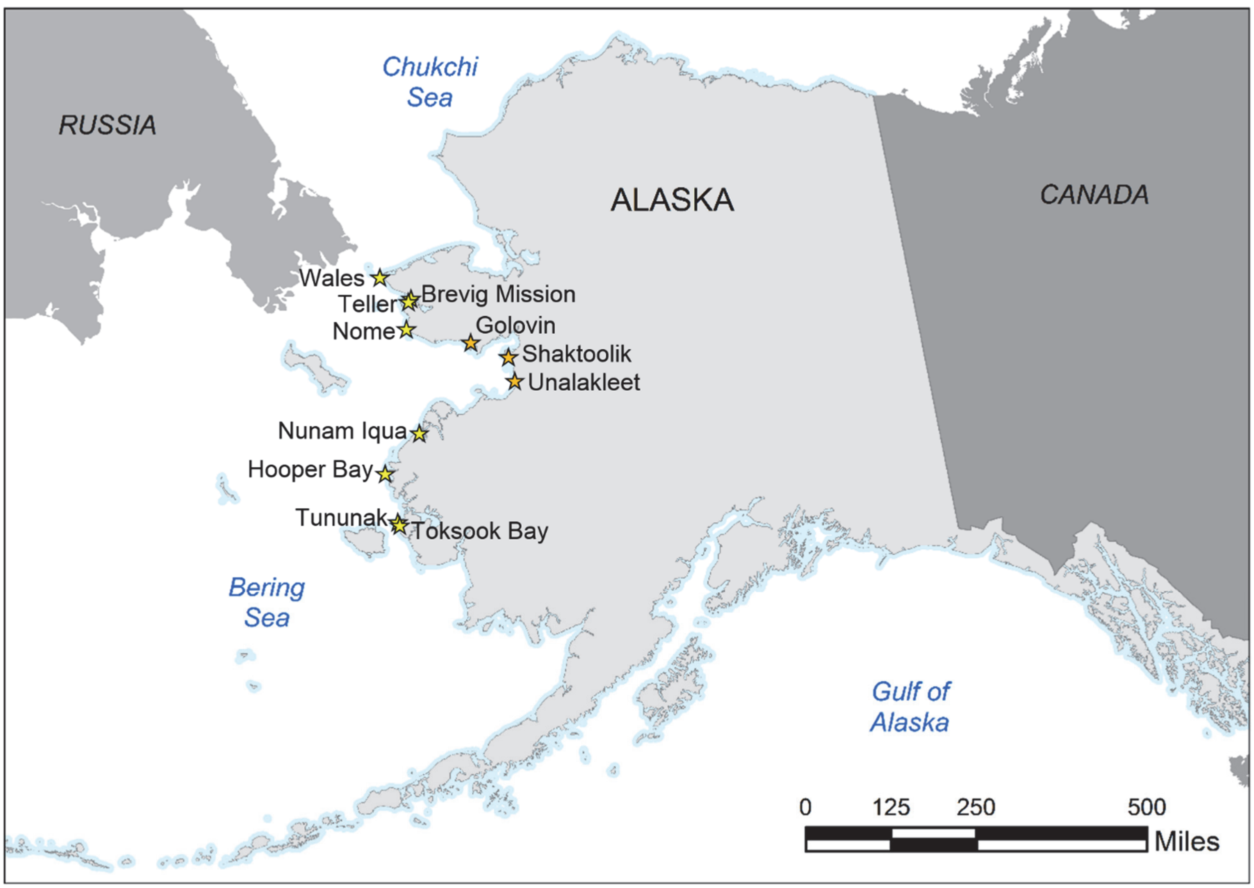

Figure 1. Map of updated (orange) and new (yellow) locations with color-indexed maps (star).

[1]Alaska Division of Geological & Geophysical Surveys
[2]National Oceanic & Atmospheric Administration National Weather Service Alaska Region

(DCRA) via the community profile map series (DCRA, 2017) along with Bristol Engineering Services for the community of Nome. Individual datasets used to create maps and their accompanying elevation conversion tables are listed throughout this document. Information on the accuracy and original source data are also referenced.

DATA SOURCES

ELEVATIONS AND ORTHOPHOTOS

Base elevations were processed from aerial photographs collected over western Alaska in 2015 (Overbeck and others, 2016). These data are digital surface models, which represent the surface of vegetation, buildings, vehicles, etc. Common elevation datasets used for flood mapping are usually bare earth models, which represent the ground surface beneath vegetation or buildings. Because a surface model was used to update this map series, there are inherent errors where flood waters are expected to flow over a bare earth surface rather than on top of vegetation. These elevation datasets, however, are the first of their kind for most of western Alaska and therefore give the best estimate for communicating about floods at individual community sites. The elevation datasets are also co-registered to orthophotos. Orthophotos are aerial images geospatially corrected to represent the earth's surface and collected in a true color composite (i.e. what you would see with your eye). The updated orthophotos are used as background images in this map series. The elevation and orthophoto datasets are more recent than other datasets used to create this map series. In some areas buildings have been moved, however, most of the delineated infrastructure are still relevant.

Elevation data were processed from their raw format to remove noise and down-sampled to streamline data processing. The raw digital surface elevations included erroneous data over water bodies and wet areas. These areas were hand delineated and removed from the dataset. The ground sample distance of the raw elevation data ranged from 8-20 cm. These high resolution datasets were down-sampled to improve data processing time resulting in ground point resolution of approximately two meters. Culverts and bridges

Figure 2. Schematic of color indices over topographic surface.

were manually edited as low elevation data points to maintain flow through these areas. A fill was then performed on the elevation data so that low-lying areas protected from floods by levee-type landforms or infrastructure would be correctly mapped. The resulting elevation models are the best estimate of where water would flow with increasing water levels.

Elevation data are represented as color indices with discrete ranges. For example, orange represents the lowest two meters of elevation data, while blue may represent the next one meter higher (fig. 2). Elevation ranges were selected based on local information, so are different for each community. Since the elevation data used to create the color indices are digital surface models rather than bare earth models, the top of a house may be a different elevation range than the floor (fig. 2). Flood waters, however, inundate the base of a building regardless of roof height, and can cause damage within an area which may be shown at a high elevation indices. Elevations near buildings may also be skewed, due to the processing method used to create them. Because the elevations are derived from aerial photographs, the sharp changes in elevation at building edges are somewhat smooth. Caution must be used when interpreting potential flood elevations relative to color-indexed elevations, particularly around buildings.

LINE WORK AND CARTOGRAPHY

Building locations and names, as well as land-use boundaries and local subsistence use areas are delineated at each community. These data were created for DCRA in their community profile map series, between 2004 and 2007. For ease of use and familiarity of local residents with the DCRA maps, formatting between the DCRA maps and this map series have been kept as similar as possible. Cartographic representations of mapped features were updated where the conversion between AutoCAD and ArcGIS was not congruent.

REFERENCE DATUMS

A datum is a base elevation used as a reference from which to measure heights or depths (NOAA, 2017a). In the case of this map series, a datum is important to relate relevant elevations of infrastructure (e.g. sewage lagoon) and the elevations of storm events (e.g. 100 year storm). For flood mapping, a conversion is necessary between a datum relative to tidal fluctuations (tidal datum) and local land elevations (land-based datums; e.g. North American Vertical Datum of 1988; NAVD88). The tidal datums represented by this map series are commonly used by coastal modelers and engineers (NOAA, 2017a):

> "*MLLW*—Mean Lower Low Water—The average of the lower low water height of each tidal day observed over the national Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the national Tidal Datum Epoch.
>
> *MSL*—Mean Sea Level—The arithmetic mean of hourly heights observed over the national Tidal Datum Epoch. Shorter series are specified in the name, e.g., monthly mean sea level and yearly mean sea level.
>
> *MHHW*—Mean Higher High Water—The average of the higer high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch." (NOAA, 2017a; fig. 3)

Elevation datasets used in this map series were referenced to NAVD88 using ground control elevation points (Overbeck and others, 2016). Tidal datums were verified by the National Oceanic and Atmospheric

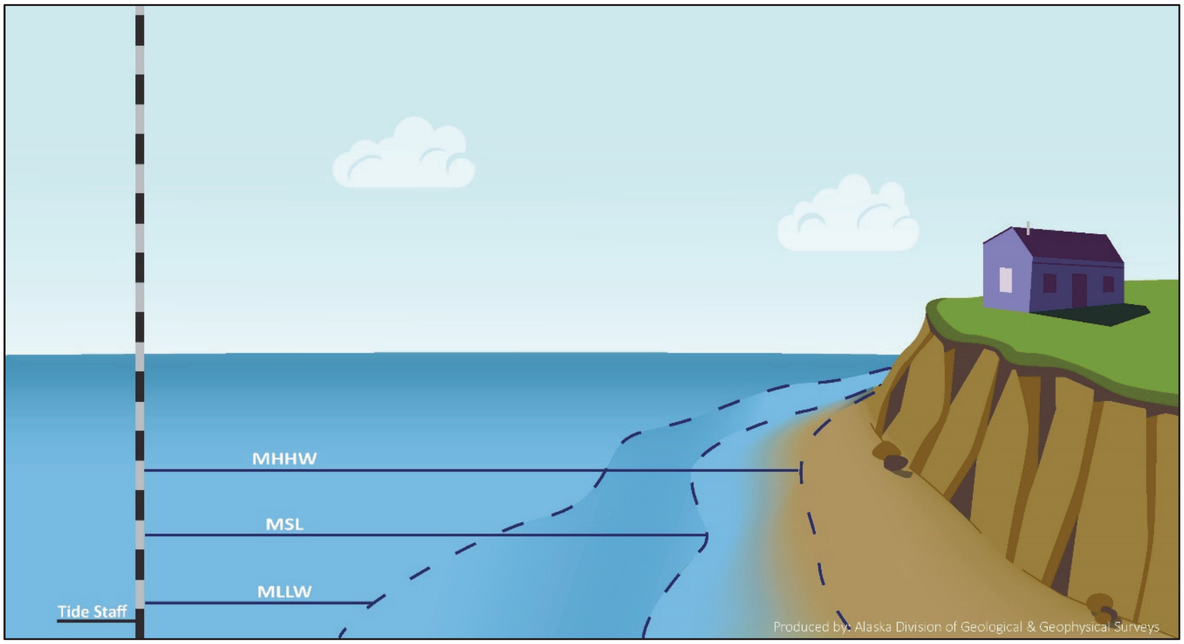

Figure 3. Schematic of alongshore tidal datum position over topographic surface.

Administration (NOAA) at 10 locations where tidal predictions are currently available (NOAA, 2017b; DGGS, 2017). The tidal datum information at Golovin was computed using an online datum calculation tool (https://www.tidaldatumtool.com/) from water level data collected in 2012 (Overbeck and others, 2015).

MODELED AND OBSERVED WATER LEVELS

There are currently no consistent standards for flood modeling in Alaska. From one community to another, different flood reporting may be available in a variety of formats. This map series uses consistent language regarding modelled and observed water levels. Inundation, or Marine Total Water Level, is defined as the sum of water levels from tides, non-tidal residuals, and wave-induced components (Moritz and others, 2016). Common model outputs for coastal inundation take into account different water level components. For the model reports used in this map series there are two main types of models, which are defined below:

Storm Surge—tides and storm surge

Wave Runup—tides, storm surge, and wave-induced water levels

Storm elevations are also often reported as return interval flooding events. A storm with a return interval of 100 years is expected to occur once in a 100 year record.

Since there is minimal observational equipment in the nearshore zone of Alaska (AOOS, 2016), many of the observed water levels were referenced to historical information about flooding collected by the U.S. Army Corps of Engineers (USACE, 2017). Floods are often reported as heights above ground elevations at well-known locations (e.g. post office). For these observations, where the location could be identified, the reported height was converted to the datum used in this map series, resulting in a generalized term for observed water levels:

Flooding—unknown water level components, where standing water was observed

Specific infrastructure elevations have been extracted and used to fill in the tide staff sheet. For example, infrastructure vulnerable to flooding, such as a sewage lagoon located near a beach front, has a minimum elevation before it is inundated. This elevation is important for community leaders, emergency managers, and forecasters to know and communicate flood risks for a given event. It also provides a path of communication to better convey peak water levels during post-event assessments.

Table 1. Source data by community map.

Community	Tidal Datum	Line work	Models/Observations
Brevig Mission	Port Clarence Station ID 9469239	DCRA (2017)	USACE Data Sheet Brevig Mission
Golovin	2012 DGGS occupation	DCRA (2017)	Chapman and others (2009); Overbeck and others (2015); USACE Data Sheet Golovin; Kinsman and DeRaps (2012)
Hooper Bay	Dall Point Station ID 9466931	DCRA (2017)	Chapman and others (2009); USACE Data Sheet Hooper Bay
Nome	Nome, Norton Sound Station ID 9468756	BEESC (2009)	Chapman and others (2009); BEESC (2009); Kinsman and DeRaps (2012)
Nunam Iqua	Nunam Iqua (Sheldon Point) Station ID 9467551	DCRA (2017)	Chapman and others (2009); USACE Data Sheet Sheldon Point
Shaktoolik	Shaktoolik Station ID 9468691	DCRA (2017)	Chapman and others (2009); USACE Data Sheet Shaktoolik; Kinsman and DeRaps (2012)
Teller	Port Clarence Station ID 9469239	DCRA (2017)	USACE Data Sheet Teller
Toksook Bay	Nelson Island, Toksook Bay Station ID 9466298	DCRA (2017)	Chapman and others (2009)
Tununak	Nelson Island, Toksook Bay Station ID 9466298	DCRA (2017)	None available
Unalakleet	Unalakleet Station ID 9468333	DCRA (2017)	Chapman and others (2009); Erikson and others (2015); USACE Data Sheet Unalakleet; Kinsman and DeRaps (2012)
Wales	Tin City, Bering Sea Station ID 9469439	DCRA (2017)	Chapman and others (2009)

REFERENCES

Alaska Ocean Observing System (AOOS), 2016, Coastal & nearshore water level observations in Alaska, http://www.aoos.org/wp-content/uploads/2011/05/2016_Alaska_Water_Level_Observations_v1-0.pdf

Bristol Environmental Engineering Services Corporation (BEESC), 2009, Nome zoning map: City of Nome, 3 sheets.

Chapman, R.S., Kim, Sung-Chan, and Mark, D.J., for U.S. Army Corps of Engineers, Alaska District, 2009, Storm damage and flooding evaluation, storm-induced water level prediction study for the western coast of Alaska: Vicksburg, Mississippi, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, 92 p.

Division of Community and Rural Affairs (DCRA), 2017, Planning & Land Management: Community Profile Maps [website], last accessed April 2017: http://commerce.alaska.gov/dnn/dcra/planninglandmanagement/communityprofilemaps.aspx

Division of Geological & Geophysical Surveys (DGGS), 2017, Alaska Tidal Datum Portal [website], last accessed April 2017: http://dggs.alaska.gov/sections/engineering/ak-tidal-datum-portal/

Erikson, L. H., McCall, R.T., van Rooijen, A., and Norris, B., 2015, Hindcast storm events in the Bering Sea for the St. Lawrence Island and Unalakleet Regions, Alaska: U.S. Geological Survey Open File Report 2015-1193, 47 p.

Kinsman, N.E.M. and DeRaps, M.R., 2012, Coastal hazard field investigations in response to the November 2011 Bering Sea storm, Norton Sound, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2012-2 v. 1.1, 51 p., 1 sheet.

Moritz, Heidi, White, Kathleen, and Gouldby, Ben, 2016, An updated USACE approach to the evaluation of coastal total water levels for present and future flood risk analysis: 3rd European Conference on Flood Risk Management, E3S Web of Conferences 7 (2016) 0102, 9 p. https://doi.org/10.1051/e3sconf/20160701012

National Oceanic and Atmospheric Administration (NOAA), 2017a, Tides & Currents, About Tidal Datums [website], last accessed May 2017: https://tidesandcurrents.noaa.gov/datum_options.html

—————2017b, Tides & Currents, Center for Operational Oceanographic Products and Services (CO-OPS) [website], last accessed May 2017: https://tidesandcurrents.noaa.gov

Overbeck, J.R., Hendricks, M.D., and Kinsman, N.E.M., 2016, Photogrammetric digital surface models and orthoimagery for 26 coastal communities of western Alaska, *in* DGGS Staff, Elevation Datasets of Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2016-1, 3 p. http://doi.org/10.14509/29548

Overbeck, J.R., Kinsman, N.E.M., and Misra, Debasmita, 2015, Coastal vulnerability of a populated arctic spit: A case study of Golovin, Alaska, USA: Shore & Beach, v. 83, no. 4, p. 35-47.

Tschetter, T.J., Kinsman, N.E.M., and Fish, A.M., 2014, Color-indexed elevation maps for flood-vulnerable coastal communities in western Alaska: Alaska Division of Geological & Geophysical Surveys Miscellaneous Publication 154, 20 p., 20 sheets, scale 1 inch – 500 feet. http://doi.org/10.14509/29129

United States Army Corps of Engineers (USACE), 2017, USACE Floodplain & Erosion Viewer [website], last accessed May 2017: https://alliedgis.maps.arcgis.com/apps/webappviewer/index.html?id=251ecb3f62524857971e30992e7cdd18